BULLETIN

ENGINEERING DEPARTMENT

NATIONAL LAMP WORKS

OF GENERAL ELECTRIC CO.

Sept. 5, 1924 Bulletin 49

Lighting the Motor Bus

lighting

By

W. C. Brown

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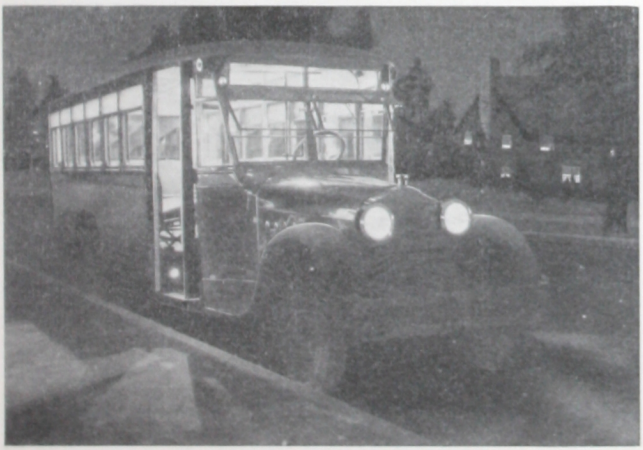
This Bulletin discusses the lighting of the bus interior; it treats as well of the various exterior lighting units—headlights, tail light, signals, step light, trouble lamp, sign, and markers—and of the wiring and other parts of the electrical circuits.

The Well-Lighted Bus Carries the Crowd

Lighting the Motor Bus

For the motor bus as a common carrier desirable standards of service are being rapidly evolved. From all public utilities appropriate standards have long been expected and in many respects required. Proper lighting has come to be recognized as one of the important elements in satisfactory bus service, and its adoption is contributing to the growing public approval accorded this form of transportation, with all that this implies in unimpeded development.

In competition with other transportation agencies, with rival bus lines, or with private cars, lighting plays a vital part in attracting new passengers and making repeaters of them. Aside from the obvious drawing power of the well lighted bus standing at the curb on a dark night, the warm, comfortable appearance of the interior gives the passenger that sense of security and well-being which is everywhere desired and demanded. He can observe the other passengers, read the advertising cards and enjoy his evening paper in comfort. The trip seems shorter, jostling is reduced, and there is less stumbling over baggage and similar obstructions. In addition



An Example of Modern Lighting Standards

to the increased patronage, good lighting has the further advantage to the operating company of discouraging petty thievery and annoyance to unescorted women, and reduces the likelihood of minor injuries with their resultant damage suits.

Obviously, where the lives of so many persons are literally in the hands of the driver, good headlighting is of extreme importance. A proper tail light is, of course, required. Electrically lighted signals, effective in bright sunlight as well as at night, and provided with means for keeping the driver informed that they are operative, minimize danger from rear end collisions in the event of sudden stops or turns. Colored marker lights at the four corners of the body near the top aid the approaching driver in his estimation of available road width. With the bus as with the private car lighting plays its important part in making night driving safe and pleasant.

Fig. 1—A Pay-Enter or Street-Car Type Bus for City and Suburban Runs

Fig. 2—A Coach or Sedan Type Bus for Interurban and Touring Service

LIGHTING THE BUS INTERIOR

The problem of lighting the interior of the bus involves considerations of limitations peculiar to this service—vibration, scant headroom, a restricted energy supply, and relatively large voltage variations.

As compared with conveyances on rails, buses are subject to considerable vibration, jolting, and swaying, particularly where the routes covered include rough roads and bad pavement. Under these conditions vision becomes more difficult. For comfortable reading it is necessary to provide an illumination of from four to eight foot-candles. Illumination of a not far different order should further be supplied for the upper side walls and ceiling in order to provide a pleasant and cheerful appearance and at the same time satisfactorily illuminate the advertising cards, which have come to be recognized as a desirable source of revenue in buses.

In buses with low ceilings, and especially in those equipped with cross-seats, proper location of the luminaires, or lighting units, to avoid the casting of shadows by the passengers on their own reading matter, is as important as furnishing enough light.

Fig. 3—The Best Lighting is Obtained with a 21-Candlepower Unit over the Center of the Back of Each Cross-Seat

Fig. 4—Where the Energy Supply is Limited, 21-Candlepower Units over the Back of Alternate Seats Give Fair Results

Best results are obtained by placing a luminaire over the center of the back of every cross-seat, as shown in Fig. 3. With well designed units in a bus with light ceiling the standard 21-candle-

Fig. 5—The Same Number of Luminaires as in Fig. 4, Improperly Placed, Cause Disagreeable Shadows and Uneven Illumination on the Reading Plane

power headlight lamp gives illumination on the reading plane which is in the upper part of the range mentioned above as necessary to sustain comfortable reading. With proper maintenance the intensity may be held within the range, except when unusual voltage conditions occur. This arrangement is in all cases to be preferred to the use of fewer units equipped with higher candlepower lamps.

Most buses in service today do not have sufficient generator capacity to permit the use of such a unit over every seat. It may be sufficient to provide only for 21-candlepower units over alternate seats, as indicated in Fig. 4. With the best equipment this arrangement gives a level of illumination which is in the lower part of the range, and which in service is likely at times to fall below. Relatively little difficulty from shadows is experienced with such spacing, and considering all cost and efficiency factors involved, this practice is substantially as satisfactory as that of using units with lower candlepower lamps over every seat. It is important that the units be placed over the backs of the seats. If, for example, the units were moved a foot or so farther ahead in the bus, the reading matter in the hands of passengers in every second seat would be shaded, as shown in Fig. 5.

Selection of the Luminaires

Available types of bus lighting equipment are analyzed as to their suitability from six standpoints. (Table I.) When luminaires that rate high from the standpoints of lighting, glare, and maintenance are used, the bus is attractive to people both on the street and in the bus.

Satisfactory illumination for the passengers' reading matter and the advertising space depends, of course, upon the total amount of light delivered by the luminaires, and the distribution of this light. High output, that is, high efficiency, is of prime importance where the energy available is so limited. It will be noted that an open reflector is in general more efficient and distributes the light to better advantage than does an enclosed unit. From the standpoint of illumination of the advertising space and the bus ceiling, it is desirable to have approximately 20% of the light output from the unit distributed above the horizontal.

Glare, that is, the interference with vision and discomfort experienced from bright lighting units, is especially marked when

low ceilings bring the luminaires close to the line of vision of passengers in the rear of the bus. It is therefore very important that the glassware be of sufficient density and the illuminated portion of sufficient size to keep the candlepower low in the direction of passengers whose eyes would ordinarily be directed toward them, and also to avoid bright spots. The use of bare lamps in the bus should never be considered. Moderately dense opal reflectors are to be preferred to those of light density. Open reflectors should be deep enough to shield the filament to at least 30 degrees below the horizontal.

Unlike carbon deposit in the motor, the coating upon the surfaces of the luminaires, caused by gradual accumulation of dust, smoke, etc., produces no "knock" to call attention to itself. Hence a large part of the light is frequently lost by absorption before the condition is remedied, yet the remedy is a very simple one. All that is needed is systematic cleaning as regularly as the bus itself is cleaned. So generally is the loss from dust and dirt not realized, that many bus companies that are meticulous regarding the general condition of their buses are neglecting this simple addition to their maintenance schedule. The limited energy supply makes the conservation of the available light doubly important. The tight-fitting enclosed unit with only one exposed surface, and that facing downwards, is the most nearly ideal unit from this standpoint. Dirt accumulations are small and cleaning is accomplished most simply and quickly. In the case of open units three surfaces are exposed to the dirt—the lamp bulb and the inside and outside of the reflector—hence the effect of dirt accumulation is materially greater and cleaning is less simple, though by no means difficult. A frosted finish collects more dirt and adds to the work of cleaning.

The obstruction offered by the units, and the theft of lamps, are considerations of lesser importance in the selection of best luminaires, and yet the possibility of injury to passengers in low-ceiling buses is an appreciable factor which becomes more serious with the deeper units and those with sharp edges. Obviously the unit must be so constructed that neither the glassware nor any other part will fall under the vibration commonly encountered in service. The enclosing units afford protection against unauthorized lamp removal. With all types of equipment locking sockets give the maximum security.

TABLE I

A GUIDE TO THE SELECTION OF LUMINAIRES FOR BUS INTERIORS

TYPE OF LUMINAIRE	RATING FROM STANDPOINT OF					
	Illumination of Passengers' Reading Matter	Illumination of Advertising Space	Glare	Maintenance	Obstruction Hazard	Theft of Lamps
 Bare Lamp	B	C	D	B	B	C_1
 Clear Prismatic Glass	B	B	C	C_2	A	A
 Diffusing Glass	B_3	B_3	A_4	A_5	A	A
 Clear Prismatic Glass	B	B	C	C_2	A	A
 Medium Density Opal Glass	A	A	A−	C	C	B_1
 Prismatic Glass, Velvet or Satin Finish Inside	A	A_6	A−	C	C	B_1

1. Rating "A" if provided with locking socket.
2. Rating "D" unless provided with dust-tight gasket between cover-glass and reflector.
3. May fall to rating "C" or "D" if inefficient glass or reflector.
4. Rating "C" if clear cover-glass.
5. Rating "C" or "D" unless provided with dust-tight gasket and glass with smooth outer surface.
6. Rating "B" if clear glass.

Characteristics of the Bus Interior Affecting Illumination

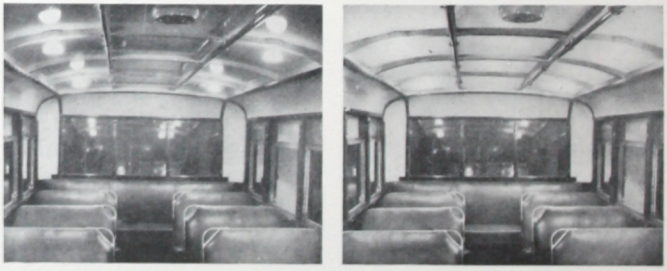
Dark colored ceilings and upper side walls should be avoided since they absorb much of the light striking them and detract from the night appearance of the bus. White is, of course, the most efficient color. (Table II.)

TABLE II

Reflection Factors of Interior Finishes

Surface Color	Reflection Factor
White Paint	70–80%
Light Oak Stain	35–45%
Dark Oak Stain	15–30%

Enamel finishes are less desirable than flat finishes because of the spotty appearance caused by reflections from the glossy surface (Fig. 6); on the other hand flat finishes collect dirt and grease more readily and are more difficult to clean. The advantages of both are retained in a finish known as semi-mat, often referred to as an "egg-shell" finish. In some paints of this type the direct reflections are reduced to such an extent that they are not objectionable, and at the same time the surface is sufficiently smooth so that dirt is not collected readily and cleaning to restore efficiency is almost as easy as in the case of the regular glossy paint or enamel.



A B

Fig. 6—(A) The White Enameled Ceiling is an Efficient Reflector and is Easily Cleaned, but the Images of the Luminaires Give it a Spotty Appearance; (B) The Semi-Mat or "Egg-Shell" Finish Retains the Advantages of the Glossy Surface and at the same Time Reflects the Light Diffusely

THE HEADLIGHTS*

Satisfactory headlighting for motor bus service depends upon two things—proper equipment and correct adjustment.

The severe vibration found on many buses requires that the headlamps be of more rugged construction than many of those made for private cars. The following physical characteristics are essential:

Housing of heavy-gauge material so constructed as to obviate warping;

Reflector of heavy-gauge brass, silver-plated, and firmly fastened to the housing;

Focusing mechanism which will not rust together nor shift position under vibration. A large, conveniently located focusing screw;

Tight fit between socket and reflector sleeve, and between socket and lamp base;

Dust and moisture-tight gasket between cover glass and reflector, which will not loosen when the glass is removed to replace a lamp;

Cover glass firmly attached, so that it cannot rotate from a vertical position;

Door so fastened that it can be removed easily for lamp replacement; preferably hinged, with a clamping arrangement which can be drawn up tight;

Solid, substantial mounting, so arranged that by loosening one nut the headlamp can be aimed readily, and the aiming remain unaltered when the nut is again tightened. (S. A. E. standard mounting.)

To obtain the proper distribution of light on the road an approved light re-directing device should be employed. The Eastern Conference of Motor Vehicle Law Administrators has classed the better devices as "Class A." These are shown in Table III.

* For complete discussion see "Importance of Better Automobile Headlamps and Proper Adjustment" by R. N. Falge and W. C. Brown, S. A. E. Journal, Vol. XIII, No. 1, Page 25.

TABLE III

LIST OF APPROVED HEADLIGHT DEVICES

Class A

Uniform Approved List

The devices in this class have been approved by the Eastern Conference of Motor Vehicle Administrators, representing the following States and Provinces, in all of which they are legal:

Connecticut	Massachusetts	Vermont
Delaware	New Hampshire	Virginia
District of Columbia	New Jersey	Province of Ontario, Canada
Maine	New York	Province of Quebec, Canada
Maryland	Pennsylvania	
	Rhode Island	

In some of these states other lenses or devices, in addition to those listed below, have been approved. If in doubt about the legality of your lens or device, communicate with the Motor Vehicle Commissioner of your state.

When properly adjusted, headlights equipped with any one of these devices will be legal in nearly all states.

Devices	Focal Adjustment
Alpheco	Principal
Bausch and Lomb	Principal
Benzer Type "A"	Principal
Brown Reflector	Special
Conaphore "F" Clear	Principal
Conaphore "F" Noviol	Principal
Deglarescope	Special*
Dillon Type I	Principal
Dodge Bros. 8⅝ only	Principal
E. & J. Type 20	Special*
Flatlite Standard Reflector	Special*
Flintex	Principal
Ford "H" 8⅛ only	Principal
Guide-Ray Type "A" Headlamp	Special*
Holophane 855	Principal
Hudson 8⅛	Principal
Johnson	Special*
Lee Knight	Principal
Legalite MIII	Principal
Liberty Type "D"	Principal
Macbeth Type "D"	Principal
McKeelite	Principal
Miro-Tilt	Principal
Monogram	Principal
Osgood B-23	Special
Parab-O-Lite Type FW	Special
Patterson	Principal
Smith	Principal
Spreadlight	Principal
Standard	Principal

* Narrowest vertical spread.

Even the best of headlighting equipment may become as useless as the worst if improperly adjusted. A very large percentage of the glare and poor illumination so much in evidence on our roads today results from improper adjustment, or lack of any attempt at adjustment. An immediate and far reaching improvement in night driving conditions would be brought about, if drivers would realize two facts:

1. With the majority of headlamps now in service it is entirely possible and practicable to get good road illumination, and at the same time avoid objectionable glare, by properly adjusting the headlamps.

2. Drivers who make the proper adjustments now, without waiting for others to make them, not only remove the annoyance they are causing others on the road, but also provide for themselves a road illumination that is better and safer, and one that makes it easier to pass cars with glaring headlamps than is now the case when they have their bright lights on.

Fortunately almost all non-glare devices in general use are designed for the same position of the bulb in the reflector, known as the "principal" focus position, as will be noted from Table III.

Where the "special" focus adjustment is specified, the instructions furnished with the device should be used. For those devices designed for the "principal" focus position, the procedure of adjustment is as follows:

1. **Use only 21-Candlepower MAZDA C Lamps**—They have closely concentrated filaments, give a white light, and maintain their candlepower in service. (Fig. 7). If blackened lamps of old types are found in the headlights, replace them.

Fig. 7—The Standard 21-Candlepower MAZDA C Headlight Lamp. Closely Concentrated, Accurately Placed Filaments are Essential for Good Headlighting

If new lamps do not give a fairly white light with the engine running at a speed corresponding to 18 or 20 m. p. h., have the battery inspected at a service-station before proceeding with the adjustment. If lamps have been burning out at short intervals, have the connections from the generator to the battery inspected. Replace any socket, fuse, or connection that is found to be defective.

2. Polish the Reflectors—Polish reflectors with a soft cloth, preferably dipped in powdered lamp black. Fogged, rusted or defective reflectors should be replaced with new ones; they should not be replated. If the gasket cord, which is provided to make an air-tight seal between the lens and the reflector is loose, fasten it back in place with shellac.

3. Focus the Lamps in the Reflectors—Some means, which can be determined upon examination, is customarily provided for moving the bulb forward and backward in the reflector. (When the focusing mechanism is eliminated and the socket is fastened permanently to the reflector, use only MAZDA No. 1101, 1102, or 1108 lamps with 6-8 volt systems and MAZDA No. 1111 or 1112 lamps with 12-16 volt systems. They are made most accurately and intended primarily for "fixed focus" service.) Adjust the bulb until the filament is placed with respect to the reflector so that the spot which is thrown on a vertical surface 25 feet ahead of the car will be of the minimum size and approximately round. (Fig. 8) With fluted reflectors that spread the light to either side, the filament is properly placed when the spot is shallowest in the vertical dimension. One point that should be kept in mind in either case is that the top of the beam should have as sharp a cut-off as possible. The results are sometimes improved by turning the lamp over in the socket.

4. Install Redirecting Equipment—When the ordinary redirecting lens is used, be sure that it is placed in the headlamp door so that the wording on it reads properly from the outside and that it is fastened securely so that it cannot rotate away from a vertical position. Where fluted reflectors are used, they in themselves accomplish the spreading of the light and require only a plain cover glass. It is important that the flutes be exactly vertical.

Install one headlamp door, with the glass properly fastened in it, on the headlamp and hold the other door loosely in front of the other headlamp in the proper position. Cover first one beam and then the other. The spots from both, as seen on the vertical surface, should look practically the same. If they do, the other door should be installed. If they are noticeably different, it means that the focus has been disturbed in installing the door, possibly due to the fact that the reflector moved back on springs while the lamp position remained the same. Re-focus the lamp on which the door has been installed so that both beams look the same. Install the other door and re-focus in the same manner.

5. Aim the Beams—Place the bus on a level stretch with a garage door or other vertical surface 25 feet ahead. Draw a horizontal line on the door at the level of the headlamp centers. Sight through the center of the rear window over the radiator cap and so determine a point on the horizontal line midway between

headlamps. Locate points at the right and left of this center point directly ahead of each headlamp, as shown by "A-A" in Fig. 8.

A universal joint or slot under one of the bolts fastening the headlamp to the fender or frame is usually provided to facilitate aiming. On a few types it may be necessary to bend the headlamp brackets. With one headlamp covered, center the spot from the other on the vertical line through the point directly ahead of it, and tilt the beam to the point where its top, or cut-off, is just below the horizontal line. In a similar manner the other headlamp should be aimed below the point directly ahead of it.

When adjustments are made properly, (Fig. 9), a shallow band of light will be thrown upon the vertical surface with its top just below the horizontal but with a low-intensity diffused light above the horizontal line. The road surface will be so well lighted

Fig. 8—Headlamps Properly Focused, Without Lenses

Fig. 9—Headlamps with Redirecting Equipment, Properly Focused and Aimed

that the driver can pass other cars conveniently and safely. It is possible that oncoming drivers may at times signal to dim. Intolerable glare has been so common in the past that whenever motorists see headlamps illuminated with a white light they expect trouble. Under some conditions, glare results even with headlamps properly adjusted, as, for example, in coming over a rise, when drivers must, of course, dim for both cars and pedestrians unless the headlamps are such as to permit tilting the beam downward.

If the driver can distinguish the faces of people in approaching cars by the light from his own headlamps, his lights are decidedly glaring.

6. Maintenance—At reasonable intervals, the adjustments should be checked by throwing the beam against a vertical surface or viewing it from about 100 feet ahead of the bus, to be sure that vibration and handling have not changed the focus and aiming. The headlamps should be re-focused and re-aimed each time a lamp is renewed.

Proper headlighting is impossible if the equipment is not kept in good condition. Whenever a lamp is renewed, and oftener if necessary, the reflectors, the lamps, and the lenses should be carefully cleaned.

THE TAIL LIGHT

The Society of Automotive Engineers and the Illuminating Engineering Society have promulgated specifications for adequate illumination of the rear number plate, compliance with which is required by some States. Various manufacturers supply equipments which meet the requirements with either 2 or 4 candlepower lamps. Glass rather than celluloid is specified as a cover for the license plate opening. The unit should be dust proof, and provided with a drain hole at the bottom to allow the escape of any moisture which may condense inside.

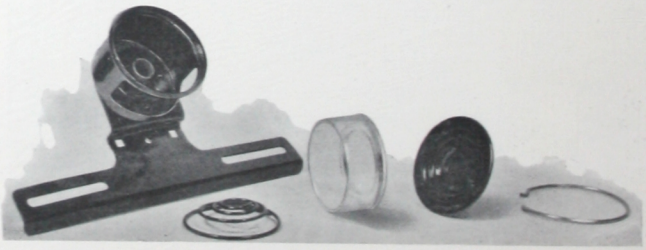


Fig. 10—Component Parts of a Good Type of Tail Light

STOP AND DIRECTION SIGNALS*

The electrically lighted signal is an essential on the motor bus, and because of the width of the body, two should be used, one on each side. Following are among the characteristics of a satisfactory signal:

Fig. 11—Stop Signal and Indicator. The Latter Shows the Driver that the Signal is Operating

It should be sufficiently bright to compel attention in the day-time;

It should not cause glare at night which is so great as to interfere materially with the vision of the driver of the car behind;

The switching device should operate so that the signal indicates the intentions of the driver as to a change of speed or direction, or both, before any change has taken place;

It should be provided with some form of reliable indicator device to keep the driver informed that it is working;

Primarily a safety device, it should above all be reliable. A minimum of attention should be required to keep it in operating condition;

Any parts requiring replacement should be readily available.

STEP LIGHTS

Fig. 12—Typical Step Light

A suitable step light assists passengers in entering and leaving the bus, particularly on dark streets. It reduces the chance of accident, and annoyances such as stepping in mud puddles, holes, etc. Where a door is employed the step light should preferably be so connected that it is automatically turned on when the door is opened.

* For detailed information see Bulletin No. 48, "Stop and Direction Signals for Motor Vehicles," Engineering Department, National Lamp Works.

THE TROUBLE LAMP

The trouble lamp, mounted on an extension reel which will reach to any point of the bus, is best appreciated when the emergency arises. The standard 21-candlepower headlight lamp should be used for this service, and the unit should include a reflector with diffusing surface back of the lamp to shield the eyes of the worker from the direct rays from the filament and increase the light upon the work.

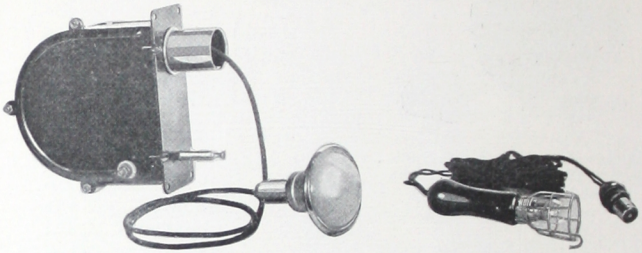


Fig. 13—A Trouble Lamp Should be Included in the Lighting Equipment of Every Bus

THE SIGN

With the box type of sign provided with a translucent cloth or other means for changing the wording readily, three 21-candlepower lamps, equally spaced, give good results for the average size sign; for longer signs the number of lamps should be increased. However, the electrical system is not ordinarily adequate for this practice. In any event three lamps should be used even though it is necessary to drop to the 4-candlepower size. The interior of the box should be painted white and sealed to keep out moisture and prevent accumulation of dust and dirt. A more effective form of sign is that in which the letters are made of translucent glass.

Fig. 14—Typical Arrangement of Sign and Markers

MARKER LIGHTS

Bus bodies are considerably wider than those of ordinary passenger cars. Marker lights, mounted at the top corners of the

body, front, rear, and sides give the drivers of passing vehicles a measure of the road width left for them. The 2-candlepower lamp behind the familiar Fresnel type of lens is sufficient for this service.

THE INCANDESCENT LAMP

Standard lamps should be used wherever possible because of their important advantages of high quality, low cost and availability. To reduce stocks of lamps at terminals to a minimum and make various lamps on the bus interchangeable the sockets should be uniformly either single or double contact, preferably single where a ground return system is used on the chassis.

Spare lamps should of course be carried to minimize annoyance and provide a safety factor in case of unexpected burnout on the road. Lamp kits of cardboard or metal are available in which an assortment of extra lamps can be carried.

Standard MAZDA lamps of 2, 4, and 21-candlepower are recommended for the various positions on the bus as follows: (See Fig. 15.)

2-Candlepower	4-Candlepower	21-Candlepower
Side	Auxiliary Head	Head
Marker	Step	Spot
Instrument	Sign	Sign
Signal Indicator		Trouble
Fare Box		Interior
Tail		Signal
		Backing

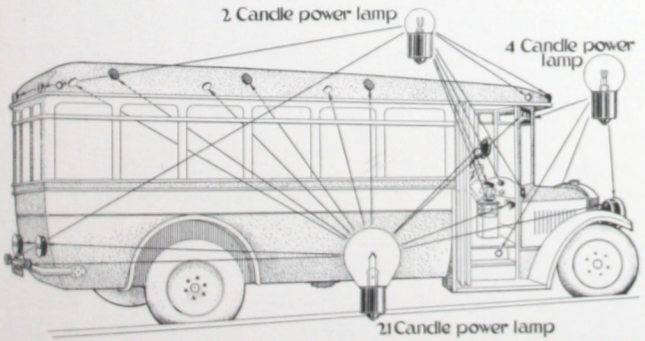


Fig. 15—Three Sizes of Standard Lamps Meet All Bus Lighting Requirements

THE ELECTRICAL SYSTEM

The electrical systems usually employed for bus service are either 6-8 volt (3-cell battery) or 12-16 volt (6-cell battery).

From the standpoint of incandescent lamp performance, 6-8 volt systems are preferable. These lamps are inherently more rugged and better able to withstand the severe vibration often encountered in bus service. Better headlighting results are obtained with the 6-8 volt lamp, as its filament is more concentrated than is that of the higher voltage lamp. It is recognized that aside from lamp considerations there are other factors to be considered in the choice of the electrical system for a bus. Not only is there the question of the relative cost and size of generator and starting motor, but there is also the factor of the larger wire required for the 6-8 volt lamps.

The Wiring

Voltage drop in the circuit, which means less voltage at the lamp filament, has a far more serious effect upon the candlepower of the lamp than is generally realized; a slight reduction in voltage produces a material reduction in candlepower. For example, with a 10% drop in voltage, *one-third* of the candlepower of the lamp is lost. Hence it is important to guard against voltage losses in the wiring, switches, fuses, sockets and connections of the circuits. Voltage drop is proportional to the current, and motor vehicle lamps, being of low voltage, necessarily draw a heavy current. The standard 6-8 volt 21-candlepower lamp, for example, while taking only 18 watts, nevertheless uses more *current* than a 300-watt lamp of the ordinary 115-volt type, and for equal candlepower loss requires an even larger current carrying capacity for the various parts of the circuit.

The wiring, therefore, should be of ample size, expecially for the interior lighting system. Not only is all the light which the system can give needed, but without large wire the last lamp of a circuit will be noticeably more dim than the first. Wires of less than No. 14 B. & S. Gauge should not be used, for mechanical reasons. This size will insure not less than 19 candlepower from each lamp if not more than four lamps are used per circuit on 12-16 volt systems. On buses with 6-8 volt systems No. 10 wire is similarly required. (See Table IV.)

TABLE IV — WIRING REQUIREMENTS

Recommended Practice—Eleven Units

Four Circuits

Permits Cutting Down to Six Units, Properly Spaced, when Energy Demands in Service are Abnormal

Recommended Practice—Six Units

Two Circuits

(3 units per circuit)

Six Units—One Circuit

Not Recommended

(6 units per circuit)

Wire Size (B. & S. Gauge)	Candlepower of Lamp B* (See illustrations above): 6-8 Volt 21-cp. Lamps		12-16 Volt 21-cp. Lamps		
	3 Units per Circuit	6 Units per Circuit	3 Units per Circuit	4 Units per Circuit	6 Units per Circuit
18	12 cp.	1 cp.	19 cp.	18 cp.	15 cp.
16	15	4	20	19	17
14	17	9	20	20	18
12	18	13	21	20	19
10	19	16	21	21	20
8	20	17	21	21	20

* Lamp "A" (See illustrations above): Operating at Rated 21-Candlepower. Wire Sizes should be such as to maintain at least 18-Candlepower on all lamps.

For the headlights, signal and other lamps of 21-candlepower, No. 14 B. & S. Gauge wire should be used. All connections should be well soldered.

Switches

A good switch has the wiping contact of a knife switch, generously designed spring members, and opens so that only air acts as the insulating material. (Fig. 16.) Whether the switch be the tumbler, push-and-pull, or position type these principles of good design should be the criteria for selection. If, as in Fig. 17, there is, in effect, a butt contact, with the current carrying member sliding onto the insulation as the circuit is opened, there is likely to be a gradual accumulation of this material and dirt on the surface of the member with consequent high resistance and heating which draws the temper from the spring finger and thus renders the contact still less effective.

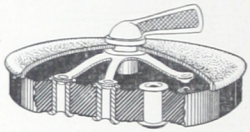


Fig. 16—With Any Type of Switch Best Service is Obtained when Substantial Spring Fingers Maintain a Firm Contact and Do Not Drag over the Insulation

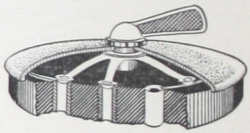


Fig. 17—A Poorly-designed Switch. Weak Spring Fingers Drag and Deposit Particles of Insulation on Studs. Butt Contacts Likely to Separate and Develop High Resistance in Service

Sockets

Good socket construction, (Fig. 18), provides a continuous path through the socket for the current and a good connection between plunger and lamp contact. The springs cannot carry current and consequently are not weakened through heating. No material is used which becomes unserviceable under moderate heat.

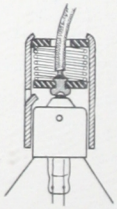


Fig. 18—A Desirable Type of Socket. Unbroken Current Path. Spring Insulated from Current-Carrying Parts

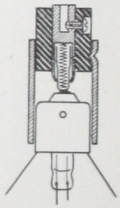


Fig. 19—An Undesirable Type of Socket. Doubtful Contact Between Plunger and Sleeve. Spring May Carry Current, Overheat and Weaken. Insulation May Soften Under heat and be Forced Out of Socket

In the undesirable types of socket, (Fig. 19) poor contact between sliding plunger and sleeve frequently cause excessive voltage drop. The heat developed at the points of poor contact may soften the rubber composition to such an extent that it is forced out of the socket by the spring pressure, rendering the whole unserviceable. The springs carrying current often overheat and weaken, and a poor connection between the plunger and lamp contact results.

Fusing

A practice, electrically equivalent to link fuses fastened firmly under binding posts, is to be recommended rather than the use of cartridge fuses and clips employing butt contacts. Due to lack of cleaning action, small area of contact, corrosion, electro-chemical action, etc., the cartridge fuse is very often the source of considerable voltage drop. If cartridge fuses are used, both fuse ferrules and clips should be nickel plated to prevent electrolytic action.

Generators and Regulators

Because of the large lighting load the generators for buses should have a capacity several times that provided for private cars. Such standard equipment is now available. In selecting the proper size, full allowance must, of course, also be made for ignition, starting, and parking requirements. Fig. 20 indicates to the bus builder the approximate generating capacities necessary to meet various desired lighting requirements, or, conversely, enables the bus builder or operator to determine the number of lamps which may safely be connected to a given capacity of generator. It should be noted that the curves are for average conditions of operation.

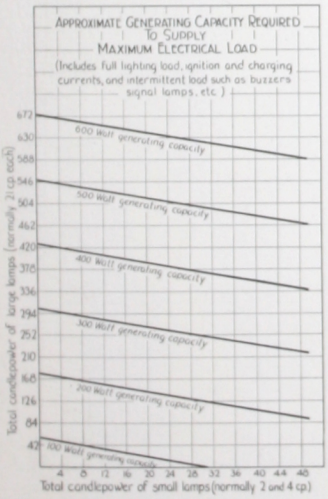


Fig. 20—Generator Capacity Required

The electrical load by day is relatively so slight that means must be provided for preventing overcharging of the battery. Voltage regulators have proven best adapted for this purpose and are coming into general use. They tend to maintain the charge of the battery and provide a more uniform voltage for the lamps.

BULLETINS OF THE NATIONAL LAMP WORKS

The purpose of the series of bulletins published by the National Lamp Works of General Electric Co. is to supply authoritative information on artificial lighting. A number of typical bulletins selected from the series are listed below.

7C—Fundamentals of Illumination Design.

This bulletin presents the principles of light—its measurement, its control and distribution—together with essentials of illumination design.—44 pages.

33B—Motion Picture Projection with MAZDA Lamps.

This bulletin discusses the optical principles involved in the projection of motion pictures by MAZDA Lamps, together with a comprehensive discussion of the lamp and the complete equipment for the most satisfactory projection. —47 pages.

41A—Illumination Design Data.

This bulletin presents a simple method of illumination design adapted to general lighting systems where standard equipment is to be used. Charts and tables simplify the work and make for accuracy in the design.—32 pages.

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Ready-made illumination designs for the more common bay sizes found in industrial interiors are presented in this bulletin.—48 pages.

45A—Lighting Designs for Stores.

Presents lighting recipes for a number of typical store interiors both large and small, together with designs and notes on lighting of the display windows.—48 pages.

46—Street Lighting and Public Safety.

This bulletin presents significant data on the relation of street lighting to traffic accidents and crime, with a discussion of effective street illumination systems for business, residence and outlying districts.—22 pages.

47—Better Electric Lighting in the Home.

A practical guide for lighting the home, replete with sketches illustrating the use of various types of lighting fixtures to obtain desirable lighting effects in the different rooms.

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